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FINAL REPORT

June 30, 1964 to September 18, 1965

DESIGN, DEVELOPMENT AND MANUFACTURE OF HIGH RELIABILITY COMPUTER GRADE MINIATURE CAPACITORS

CONTRACT NO. NAS8-11701

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Four types of capacitors were considered during the course of the contract period as possible candidates to fulfill the performance characteristics of the high-reliability unit required under this contract. They consisted of:

1) A thin film of polyurethane deposited on aluminum foil, metallized and wound.
2) Layers of thin pieces of a special barium titanate ceramic stacked in parallel.
3) Thin films of barium, strontium and titanium oxides stacked in parallel.
4) A non-electrolytic anodized tantalum foil capacitor either wound or layered.

For the first six months, each of these designs was examined in a series of experiments in which the electrical properties were measured and some prototypes built. In February 1965 at a meeting at the George C. Marshall Space Flight Center in Huntsville, Alabama, it was decided to eliminate the plastic film and stacked barium titanate approach and concentrate on the other two. Finally, toward the end of the contract period, all our effort was focused on the non-electrolytic tantalum capacitor, since it was felt that this device had the best chance of meeting the contract requirements.

What follows is a summary of the experimental work performed for each of the four capacitor types and an evaluation of the results of this work.

I. POLYURETHANE FILM CAPACITORS

After carefully examining the literature dealing with thin organic films* and taking into consideration our past research effort in this field, it was decided to concentrate all our evaluation of organic films on polyurethane. This plastic is noted for its excellent electrical properties and stability at high temperature and is available in films 0.13 mils thick, supported on 0.22 mils aluminum foil. A rough calculation of the dimensions of the package that should be obtained on winding this lacquered foil to 1 μfd. showed that it would be somewhat out of the size specifications. This calculation was based on a dielectric constant value of 3.8, which had yet to be verified, and the assumption that the coated foil could be metallized on both sides with either aluminum or zinc. The configuration that was envisaged was as follows:

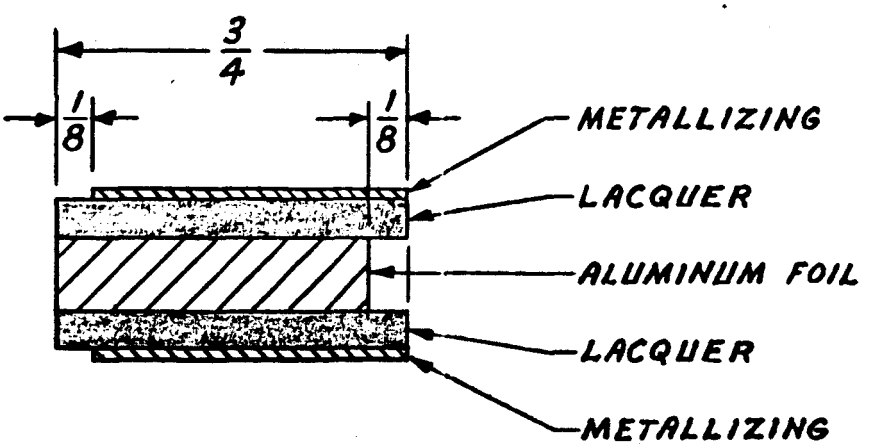

Fig. 1

It was further assumed that a margin could be etched on one side of the aluminum foil as shown in the above drawing.

* A bibliography on this subject was prepared and appears in the monthly report August 31 to September 30, 1964.

Although even at best the capacitor would be out of the size specifications, it was decided to proceed with the work, since it was felt that if the electrical properties were satisfactory, the fact that the unit was slightly too large would not completely preclude its acceptance.

The initial experiments determined the properties of the polyurethane film prior to winding. Small areas of aluminum (1.23 sq. in.) were deposited on the plastic film and Cap., DF, and IR were measured by making contact to the deposited aluminum film with an indium probe. The values obtained were:

Capacitance	7 nf per sq. in.
D.F.	0.85%
IR (150V, 125°C)	1.5×10^9 ohms and stable
150V, 85°C	150×10^9 ohms
T.C.	29% from -55°C to 125°C

The first wound section consisted of two foils wound together and staggered 1/8" since a method for etching a margin had not been devised as yet. The ends of the winding were sprayed with silver paint to make contact to the two aluminum foil electrodes. The dielectric in such a construction has double the thickness of the polyurethane film and consequently the volume efficiency is reduced markedly. Yet, a 0.86 μfd. capacitor was built 1-3/16" long x 5/8" in diameter on an oversized mandril, 3/8" in diameter. The electrical properties of such a capacitor as would be expected were quite good:

a DF $\cong$ 0.8% and an I.R. at 150 V, 125°C of 3×10^7 ohms.

The capacitor also displayed stability at voltage and temperature for a prolonged period of time.

The second type of wound capacitor constructed consisted of aluminum foil laid on the lacquered film and acting as the other electrode. Although the capacitance of such a unit is reduced because of the air film between the aluminum and dielectric film, the value obtained was 1 μfd. for a capacitor 1" long and 3/8" in diameter. The mandril in this case was 1/8" in diameter. The dissipation factor was 0.8% while the insulation resistance measured at 125 V, 85°C was 10^8 ohms. At 125°C at the same voltage the unit shorted. These IR results were considered encouraging in view of the fact that this type of capacitor cannot be cleared. Only a capacitor having a metallized film electrode can be cleared. The temperature coefficient of this unit was similar to the value obtained on the small area device, viz. 29% between the temperature limits. Between -55° and +85°C, the change is only 10%. Over the range 85° - 125°C, the change is most pronounced.

A great deal of work was expended devising a process for etching a margin in one edge of the foil. An electro-chemical method was adopted and was shown to satisfactorily etch a uniform margin. However, when the technique was applied to an unwound roll of lacquered foil, it was discovered that salts from the bath deposited on the foil and only by unwinding the roll and running it through a wash solution could the salts be removed. Equipment to accomplish this cleaning was not available, but an attempt was made to metallize one roll after a margin had been etched, but with little success.

In conclusion, then, it can be stated that:

1) The polyurethane film, if properly cleared, can operate at 150 V, 125°C for prolonged periods of time while exhibiting acceptable insulation resistance values.

2) The change in capacitance over the temperature range -55, +125°C of polyurethane is much greater than called for by the specification of the contract, viz. 29%.

3) A wound metallized polyurethane film capacitor would operate successfully within the temperature and voltage requirement of the contract, if the lacquered foil could be cleaned after the etching of a margin.

4) The size of the capacitor, fully encapsulated, would be slightly larger than the specification of the contract, around 1-1/4" x 3/8".